**BONANZA POWER PLANT**

**COAL FLAME STABILIZER**

**PROPOSAL**

for

Deseret Generation & Transmission Cooperative
P O Box 1098
Vernal, UT 84078-1089

Attn: Mr. Daniel R. Howell

Proposal No. 961431A
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dgtbfs.prx/m

*Reliability and performance solutions*

By
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## 1.0 INTRODUCTION

Deseret Generation and Transmission Coop. (DG&T) has Foster Wheeler burners on Bonanza Power Plant and has a need to reduce $NO_x$ by 10%. The Foster Wheeler burners are of the split flame design, utilizing four (4) fingers of coal at the exit for combustion. DG&T requested RJM Corporation to provide a proposal for twenty (20) coal flame stabilizers for these burners. This proposal is in response to that request.

## 2.0 OBJECTIVES

The program objectives are as follows:

1. Reduce $NO_x$ emissions by 10%.
2. Reduce LOI.
3. Improve flame stability.
4. Lower operating $O_2$.

## 3.0 COAL FLAME STABILIZERS

Modifications to the existing burners to convert the secondary air zone into two (2) separate zones are effective in reducing $NO_x$ emissions. This is accomplished by the use of a flame stabilizer mounted on the outside of the coal pipes. The flame stabilizer will create the minimum swirl necessary to maintain a stable fire while allowing the remaining secondary air to be injected in a low or non-swirl mode outside the primary combustion zone. This will effectively control the quantity of air in the primary combustion zone where the majority of the $NO_x$ emissions are formed. The coal flame stabilizer is a patented, commercial product of RJM Corporation installed on over 2600 MW of coal-fired utility boilers.

To enhance the $NO_x$ reduction capabilities of the burner modifications, the flame stabilizer will be designed with internal air staging. This will set up fuel rich and lean zones downstream of the stabilizer in the primary combustion zone, providing additional staging and, therefore, lower $NO_x$ emissions.

The swirl number of the burner can be controlled to the minimum required to achieve a stable fire and ensure reasonable LOIs by the geometric design of the swirler. The addition of the flame stabilizer will split the existing secondary air zone of the burner into a two-zone system. The inner-zone secondary air is the air going through the flame stabilizer which is required for achieving a stable flame. Outer-zone secondary air is the air going around the outside of the flame stabilizer which is used for staging the combustion to reduce $NO_x$ emissions. The optimal ratio will be determined during the design stage.

The coal flame stabilizer is a patented vane cascade device optimized for performance on the existing burners. Installing a coal flame stabilizer produces the following benefits:

1. Stable Flame Front - The coal flame stabilizer creates a cyclonic vortex which aerodynamically stabilizes the flame front in a fixed position. The flame front location is one-half burner throat diameter downstream of the burner throat. The flame front is stable over the turndown range of the burner. Absolute control of flame stabilizing dynamics is provided by the flame stabilizer. Undesirable over swirl at the burner throat and pulverized coal tube regions are avoided.

2. The coal flame stabilizer converts conventional single-zone coal burners into two-zone low $NO_X$ type burners.

3. Internal staging of the coal flame stabilizers in accordance with the latest findings of the International Flame Research Foundation, the American Flame Research Council, and other leading research organizations, permits operation of coal-fired units at very low $NO_X$ levels without significant impact on unit heat rate. On some units heat rate improvements are achieved because excess air levels can be reduced.

4. Windbox-to-Furnace Differential Pressures - The coal flame stabilizer can be designed to optimize burner windbox-to-furnace differential pressures. Excessively low windbox-to-furnace differential pressures can be raised to optimized combustion efficiencies within existing forced draft fan characteristics and limitations. The use of secondary air pressure control rings on the outside diameter of the flame stabilizer will be used to control burner draft loss.

5. Flame Shape - Aerodynamic characteristics of the coal flame stabilizer are designed to maximize flame shape for your particular furnace type.

6. Easy Installation - The coal flame stabilizer is a vane cascade device fabricated with high temperature resistant materials. The stabilizer slides onto the

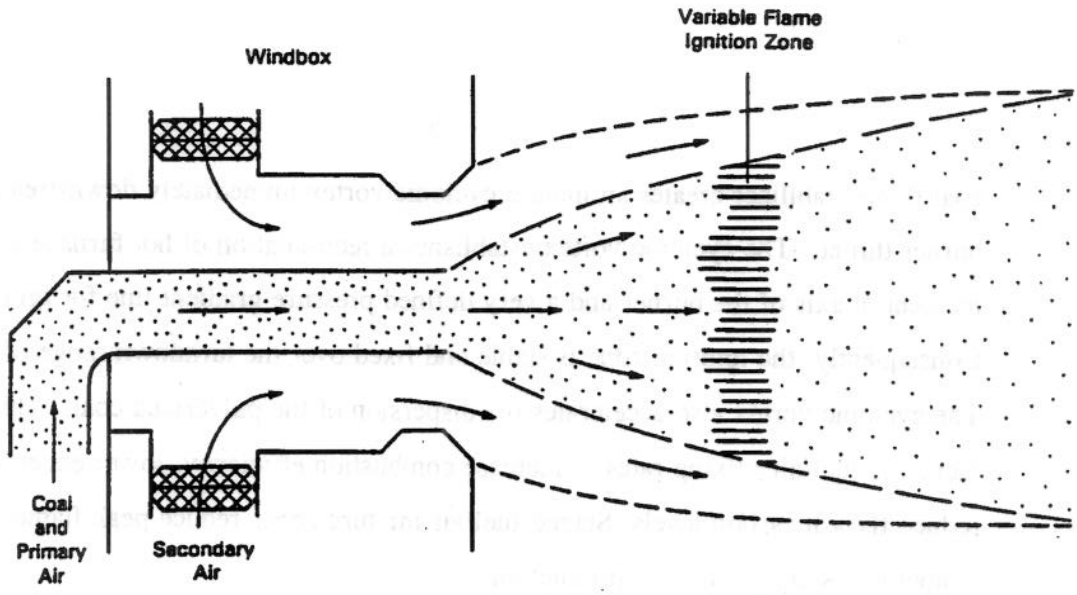
pulverized coal burner tube where it is welded into place. Installation or removal is accomplished within minutes without any modification to the existing burner.

7. Combustion Efficiency - The coal flame stabilizer device controls burner swirl number and increases recirculation rates in the flame front so that both fly ash carbon levels and excess air rates are reduced.

Figures 1 and 2 demonstrate the difference in performance characteristics of a pulverized coal burner when a coal flame stabilizer is installed. Figure 1 is in a conventional, single-zone pulverized coal burner. The pulverized coal is dispersed into the secondary air stream by primary air expansion forces and/or mechanical coal spreaders installed in the pulverized coal tube. Fuel/air mixing is slow and flames tend to be long and narrow. The flame ignition zone is variable as it is established at the point where the flame propagation speed equals the air/fuel velocity.

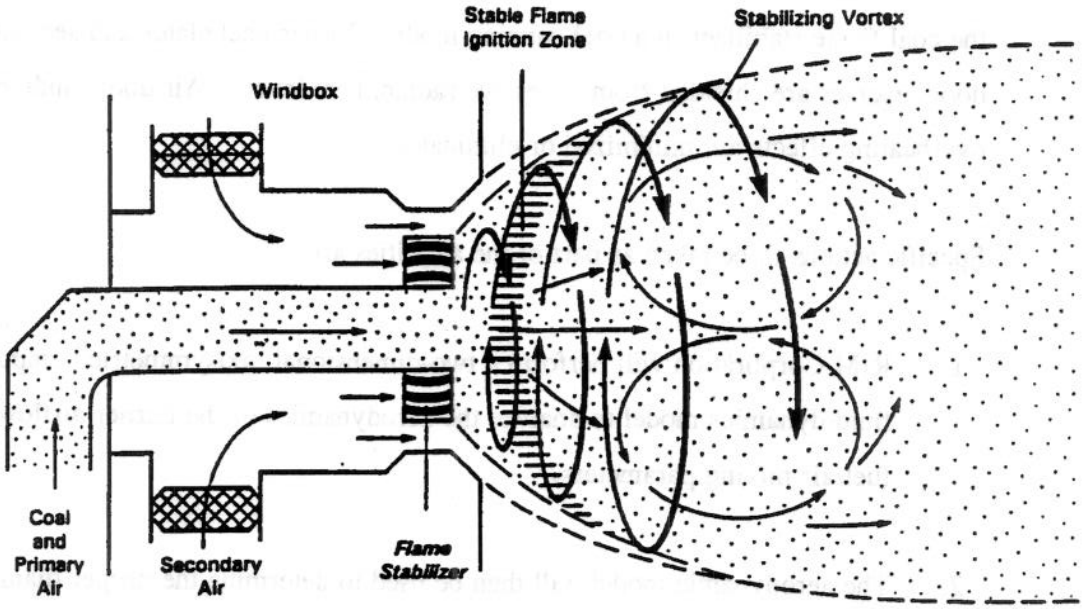
Changes in load, coal pipe instabilities and/or pulsations in windbox-to-furnace differential pressures can create substantial movement of this ignition zone. Combustion rumble and noticeable movement in furnace membrane walls results. Secondary air doors can sometimes be throttled to create a swirl which helps to stabilize the ignition zone. However, in many cases, the position at which optimum swirl for the combustion process is achieved results in burn-back of the pulverized coal tube, overheating, binding of air doors and warping of the burner components.

Figure 2 shows a conventional pulverized coal burner which has been converted to a two-zone low $NO_x$ burner by installation of a staged, air/fuel coal flame stabilizer device. Swirl is controlled at the burner throat by passing a portion of the secondary air through the vane cascade of the coal flame stabilizer. The swirl produced by the




## Conventional Pulverized Coal Burner

Figure 1




## Pulverized Coal Burner with Coal Flame Stabilizer

Figure 2

coal flame stabilizer creates an intense cyclonic vortex immediately downstream of the burner throat. The cyclonic vortex establishes a recirculation of hot furnace gases up the central axis of the burner and a very defined pressure gradient line for ignition. Consequently, the ignition zone is stable and fixed over the turndown range of the unit. The cyclonic vortex also accelerates the dispersion of the pulverized coal. This increases fuel/air mixing rates to increase combustion efficiency, lower excess air and reduce fly-ash carbon levels. Staged fuel/air mixture zones reduce peak flame temperatures and limit $NO_X$ production.

The staged coal flame stabilizer has multi-curvature vane, aerodynamic technology. Like turbine blade design the multi-curvature vanes have a variable rate of curvature from the root of the vane to the tip of the vane. This technology allows precise positioning of the ignition zone to prevent overheating or burn-back of burner components. High temperature stainless steel components, coupled with the exceptional cooling characteristics of this high-flow, high-efficiency device maintains the coal flame stabilizer in a cool running mode. Burner backplates and secondary air door linkages are shielded from excessive radiant heat levels. Air door binding due to overheating effects are minimized or eliminated.

Specific actions to be taken as part of the activities are:

1. RJM Corporation will perform a two-dimensional, axisymmetric computational fluid dynamics model to analyze the aerodynamics of the burner airflow and fuel/air mixing parameters.

2. The aerodynamic model will then be used to determine the proper diameter of the flame stabilizer. Design guidelines require that a minimum of 16% of the burner airflow should pass through the flame stabilizing cascade.

3. The proper swirl factor for the burner and flame stabilizer will be established. In fitting the swirler vane angles, the hub region of the vane cascade will be set more open than the tip using the multi-curvature vane technique. This enhances the amount of airflow at the hub and ensures the recirculation zone length will meet design guidelines. Vane cross-sections are compound curved to match inlet airflow angles, reducing the vane cascade losses.

4. Numerous vane settings will be investigated to establish the correct recirculation parameter. Recirculation parameter is defined as the difference between axial air momentum and the adverse static pressure gradient going into the furnace. Maintaining a slightly positive recirculation parameter will ensure a stable recirculation zone, good carbon burn-out and low excess air operation (without detrimental back-flow through the swirler).

5. Based on results from the aerodynamic model, final engineering drawings will be prepared and a complete set of twenty (20) coal flame stabilizers will be manufactured for installation by DG&T.

6. DG&T will install the flame stabilizers on the existing burners. The flame stabilizers slide over the pulverized coal tube and are mounted to the end using welded clips. Flame stabilizers in the past have been installed using sky-climbers, however, furnace scaffolding would be a preferred method of installation. Significantly out-of-round pulverized coal tubes would need to be reshaped or replaced prior to mounting. Extensions to the existing coal pipes or throat geometry changes may be required. This would be determined during the engineering stage. These modifications would be performed by DG&T.

## 4.0 COMMERCIAL TERMS

### 4.1 Program Cost

RJM Corporation will perform the program outlined in this proposal for the fixed price shown below in accordance with our Fees and Scope of Service and Commercial Terms and Conditions schedules located in the Appendix.

| | |
|---|---|
| Coal Flame Stabilizers | |
| Engineering | $15,000 |
| Twenty (20) Coal Flame Stabilizers | 58,800 |
| Total Program Cost | $73,800 |

All prices are quoted exclusive of state and local sales, excise, use or any other taxes. Such taxes, if applicable, will be in addition to the above prices and will be charged to your account. Any taxes assessed to RJM Corporation at a later date will be charged to your account. If the above items are tax exempt, the applicable tax exemption certificate is to be sent to RJM Corporation with your purchase order.

### 4.2 Program Schedule

The above can be completed in approximately twelve to sixteen (12-16) weeks after the receipt of your authorization to proceed and all required information. Manpower loading at the time the order is received may affect this schedule.

### 4.3 Terms of Payment

Twenty percent (20%) of the contract price shall accompany your written purchase order. The remaining eighty percent (80%) shall be paid in progress payments upon completion of each phase or portion of phase.

### 4.4 Validity

This proposal is valid for acceptance for sixty (60) days.

# 5.0 APPENDIX

# RJM CORPORATION
# FEES AND SCOPE OF SERVICE

## Personnel Rates

Personnel rates are charged on an hourly portal-to-portal basis as follows:

| | | |
|---|---|---|
| Principal Engineer | - | $150/hr in 1/2 hour increments |
| Engineer | - | $110/hr in 1/2 hour increments |
| Technician | - | $ 80/hr in 1/2 hour increments |

## Time and Materials Rates

For Time and Materials projects time will be charged at the actual applicable personnel rates. Any required materials or expenses will be billed at cost plus fifteen percent (15%).

## Minimum Daily Charges

Minimum daily field personnel charges are eight (8) hours per day per person at the applicable category rate, except for travel day charges which are based on hours actually spent. Weekend travel days are charged on a minimum-daily-charge basis.

## Expenses

Per-diem charges per person for field personnel are the greater of $100 per day or $50 above the cost of hotel accommodations. Hotel accommodations shall be charged at cost plus ten percent (10%). Automobile expenses are charged at 35 cents per mile plus tolls. All other travel costs such as air fares, car rental, taxis, parking, etc. are charged at cost plus ten percent (10%).

## Commencement

No services or manufacture shall be initiated by RJM until RJM shall be in receipt of a written commitment for the quoted amount together with initial payment of the amount specified below under "Payments."

## Air Distribution Analysis and Balancing Programs

Windbox-burner and air distribution programs are conducted on a fixed fee basis which includes all personnel, equipment, travel and per diem charges. Corrective engineering and testing beyond the initial analysis is charged at a per burner rate. For each program, RJM will furnish a budget estimate.

## Research and Development Programs

RJM undertakes Research and Development Programs only on a time-and-materials basis due to the uncertainties inherent in such programs. For each such program, RJM will furnish a best estimate budget. RJM will charge against this budget only for time spent and cost incurred. Should a program require funding in excess of the budget estimate, the Client will be notified for written approval of a new budget prior to initiating any work which would incur charges above the old budget.

## Long Term Projects

Once each project year all projects are subject to escalation of the budget estimate on a prorated basis in accordance with any revised RJM or subcontractor personnel rates or expense schedules issued in that project year.

## Delays and Delivery

All delays in field projects are charged at the minimum daily rate plus per diem and applicable travel expense.

## "Not to Exceed" Orders

Under "not to exceed" purchase orders or commitments RJM shall notify the client if additional funds are required to complete the project. RJM shall terminate field services timely to allow personnel to return to the base facility before the limit is exceeded if the client has not authorized additional money. Client shall furnish RJM with an additional written commitment or purchase order prior to RJM's continued field services, engineering or manufacturing after termination on account of "not to exceed" limitations.

## Test Work

Fixed prices for test work do not include pre-test or post-test conferences or consulting services follow-up for which RJM standard rates shall apply.

# RJM CORPORATION
# FEES AND SCOPE OF SERVICE

## Payments

Terms of payment are twenty percent (20%) with the purchase order. Invoiced payments are due in full within twenty (20) days of the date of invoice. Overdue accounts shall accrue interest at the rate of one and one-half percent (1 1/2%) per month of the unpaid balance thereof and any payment on account thereof shall first be applied against such interest.

## Taxes

All prices are exclusive of state and local sales, excise, use or any other taxes. Such taxes, if applicable, are in addition to quoted prices and will be charged to the Client. Any taxes assessed to RJM at a later date will be charged to the Client. If products or services are tax exempt, the applicable tax exemption certificate shall be submitted to RJM with the Client's purchase order.

## Shipping and Insurance

All products are shipped F.O.B. factory. Client shall advise if insurance is required. Shipping and insurance charges will be charged to Client. Client assumes risk of loss of products when shipped and recourse may be sought by Client only against the carrier's insurer. Absent instructions in writing from Client, methods of packing and shipping and choice of carrier and routing shall be determined by RJM in its sole discretion.

# RJM CORPORATION
# COMMERCIAL TERMS AND CONDITIONS

## Quotations - Scope and Content

RJM Corporation (RJM) quotations and proposals shall remain valid for acceptance for a period of 30 days from date of issue. The price quoted is subject to change with changes in project scope, quantities, materials and design. All quotations are subject to conditions listed below under "Delays."

## Acceptance and Authorization

No order or change therein or of RJM's proposal is binding on RJM until signed or acknowledged in writing by an authorized representative of RJM at its home office. Proposals or counterproposals shall not be deemed accepted by RJM by mere passage of time. Exception to provisions in RJM's proposal must be set forth in a writing received by RJM and specifically taking exception to such provisions. RJM proposals shall be limited to the contents of written proposals. All drawings, brochures, descriptive matter, weights, dimensions, shipping specifications and the like furnished by RJM with the proposal are approximate only, merely intended to describe generally the product or service and will not constitute a part of any contract.

## Delays and Delivery

When RJM is directly responsible for the delay, such as due to failure of RJM test equipment, no delay time or minimum rates apply. Delivery, shipment and installation dates of products are estimated dates only. Delays caused by any conditions beyond RJM direct control, such as partial or complete process shutdowns or irregularities, strikes, floods, fires, power failures, inclement weather, or failure of the client to meet agreed responsibilities, will be billed at standard rates in the case of services and in the case of products shall extend the estimated delivery date. RJM shall in no event be liable for demurrage.

## Cancellation

Client may cancel this contract effective upon notice to RJM as provided below under "Notice." Thereupon RJM shall cease all work, cancel all revocable subcontracts, and prepare final billing. For Time and Materials contracts the billings shall be for the time and materials expended by or for which RJM shall have incurred a liability as of the date of cancellation. For Fixed Price Contracts, client shall pay RJM the cancellation charge specified in the proposal or if no such charge shall be specified, such equitable portion of the contract price as shall be equivalent to the percentage of work completed under the contract upon notice of cancellation. For all canceled contracts, RJM shall be reimbursed for its costs incurred to effect the cancellation.

## Indemnification *(added 5/23/95)*

Client and RJM each agree to indemnify defend and hold harmless the other from and against any and all claims, losses, liability, cost or expenses, including reasonable attorneys' fees, arising out of bodily injury of any person, including death, or Company's property damage but only to the extent that such claims, losses, liability costs or expenses are caused by negligence, misconduct or other fault of its employees, agents, employees of contractors.

## Patent Infringement

RJM shall defend or settle any claim or suit brought against client to the extent it is based upon an allegation that a product sold to Client in the form manufactured by or to the design of RJM and without regard to the use by client of such product, infringes a United States issued patent, provided such product was not fabricated to the design, drawings and specifications of client. If RJM is notified promptly in writing and given information, assistance and the sole authority to defend or settle, RJM shall pay all costs of defense subject to the limitations of liability above. If the product is determined to infringe, RJM shall at its option: (a) obtain the right to continue using the product, (b) replace the product with a noninfringing product, (c) modify the product so it is noninfringing, or (d) grant client a credit for the depreciated value of the product as returned. The foregoing states the entire liability of RJM for patent infringement.

## Proprietary Technology and Data

RJM reserves all rights in and to all invention devices, concepts, processes, products or other patentable or proprietary technology and data conceived or developed by RJM, its employees, agents or subcontractors in the course of performing any contract. Neither Client nor any other person shall have any right to examine or audit RJM's cost accounts, books or records of any kind, or be entitled to have control over or rights in, any engineering or production prints, software, drawings, designs or data which RJM shall in its sole discretion deem proprietary to it. Rights in RJM intellectual property may be acquired on a negotiated basis.

## Warranty - Services

RJM represents and warrants that its procedures are generally accepted practices and methods and its personnel are qualified to effect such procedures. Tests are performed on a best-efforts basis and RJM assumes no liability for deviations required by existing conditions beyond its control or field of responsibility. No guarantee or warranty is issued, implied or intended and no responsibility is assumed for testing other than the accuracy of observed results. Should RJM's testing be materially defective, the sole liability of RJM shall be to repeat said test run at no additional cost to Client, provided, however, that said test run was not defective because of a failure of Client to supply critical information or to fulfill responsibilities.

# RJM CORPORATION
# COMMERCIAL TERMS AND CONDITIONS

## Warranty - Products

RJM represents and warrants that (a) products manufactured by it shall be (i) free of defects in materials and workmanship for a period of sixty (60) days from date of shipment to client and (ii) shall conform in all material respects to the specifications for such product agreed upon in this contract. For products not manufactured by RJM the original manufacturers warranty, if any, shall be assigned to client to the extent permitted and such assigned warranty shall be in lieu of any other warranty express or implied. RJM Corporation's sole liability hereunder shall be during the sixty (60) day product warranty period to repair or replace, at its option, products that are defective or non-conforming to agreed specifications. RJM shall have no liability for removal, transportation and replacement of such products.

## Limitation and Disclaimer of Warranties

RJM shall not be liable under the warranties hereunder unless:

(a) Client promptly notifies RJM in writing of the alleged deficiency in the product or service and offers RJM a reasonable opportunity to cure such deficiency, and (b) if a product deficiency in an RJM manufactured product, RJM inspection verifies the existence of the deficiency and determines it was not caused by damage or destruction, including any occurring while in shipment, improper installation, testing or repair (including any repair not by RJM agents or employees or otherwise not consented to in writing by RJM), misuse, neglect, or alteration.

THESE WARRANTIES ARE IN LIEU OF AND RJM DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WRITTEN OR ORAL, INCLUDING THOSE OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR OTHERWISE, AND MAY BE MODIFIED BY RJM ONLY IN A WRITING SIGNED BY RJM IN WHICH IT INTENDS TO BE BOUND.

## Limitation of Liability

RJM SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON BREACH OF CONTRACT OR WARRANTY, NEGLIGENCE, OR ANY OTHER MATTER RELATING TO THIS CONTRACT. RJM'S MAXIMUM LIABILITY SHALL IN NO CASE EXCEED THE AMOUNT THAT HAS BEEN PAID TO RJM FOR THE PRODUCT OR SERVICE PRIOR TO THE EVENT WHICH RESULTS IN SUCH LIABILITY OR, FOR INSURED MATTERS, THE AMOUNT OF SUCH INSURANCE.

The prices quoted in this sale were determined in part on the basis that RJM's liabilities and Client's remedies are limited as provided in this Statement and the prices would have been substantially different had those limitations not been agreed.

## Governing Law and Disputes

This contract and all questions arising therefrom shall be governed by and interpreted in accordance with the laws of the State of Connecticut.

All disputes arising out of or concerning this contract and the resulting sale shall be determined by arbitration before a single arbitrator in Fairfield County, Connecticut under the rules then obtaining of the American Arbitration Association and any award in such arbitration may be entered in or an application for judicial enforcement of such award may be applied for, in any court having jurisdiction of the party against whom enforcement is sought. The arbitrator shall have no power to award any special, incidental, consequential or punitive damages. It is the intention of the parties irrevocably to submit to arbitration, notwithstanding the contrary provisions of any Federal, State or local law from time to time in effect. RJM shall be entitled to reasonable attorney's fees and costs incurred in the assertion in any proceeding of a claim or counterclaim for goods and services.

## Assignment

Client may not assign any interest or right or delegate any obligation hereunder absent the prior written consent of RJM.

## Waiver

Failure by RJM to insist upon performance of any term or condition in the proposal or in this Statement shall not constitute a waiver of other terms or conditions or operate as a continuing waiver.

## Severability

Failure to deliver any installment due or any defect in delivery or service by RJM constitutes a severable breach only and the Client cannot treat the entire contract as breached unless the goods or services not delivered or defective represent at least fifty-one percent (51%) of the contract price. If an adjustment is made for any failure to deliver, or any defective delivery, or replacement thereof, such default or defective delivery shall thereafter be treated as if it had not occurred.

## Notice

Notice hereunder shall be made only in writing to the addresses set forth in the RJM proposal and in the purchase order or equivalent document of Client, or to such other address as may by notice hereunder be furnished from one party to the other, and shall be effective, (a) immediately, if by hand or by facsimile transmission and expressly acknowledged by signature of the recipient, and (b) on receipt, if mailed postage prepaid, registered or certified, first class, return receipt requested.